VOL. 10, NO. 24, 2017
ISSN 1936-8798/$36.00

Letters

RESEARCH CORRESPONDENCE

40 Years of Percutaneous Coronary Intervention

A Historical Remark on the Development and Evolution of Guidewire Technology

If somebody is asked about the most important steps in the evolution of percutaneous coronary interventions (PCI), the answer might be: 1) coronary angiography by Mason Sones in 1957; 2) the non-compliant balloon and first angioplasty by Andreas Grüntzig in 1977; and 3) coronary stenting by Ulrich Sigwart in 1986. Guidewire technology will hardly be mentioned although this is used routinely today and without dramatic evolution. It was, however, not present from the beginning. Instead, the non-compliant balloon system introduced by Grüntzig was a balloon mounted onto a catheter that had short (10-mm) wire fixed to the catheter tip. To steer this catheter into an obstructed artery was a difficult maneuver. Therefore, the very first procedures of PCI were performed only in patients with proximal stenoses.

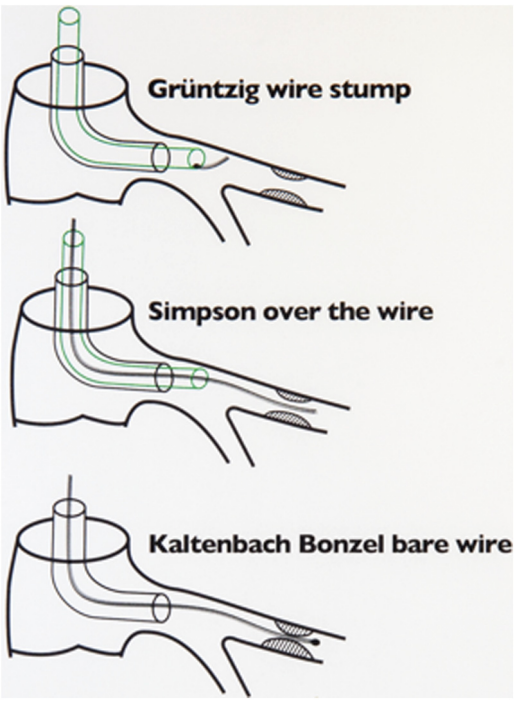
John Simpson used the Grüntzig catheter with a movable wire instead of the fixed stump. Despite this improvement, PCI remained difficult. Even years after the first procedures performed by Grüntzig, few centers had collected a broader experience (1). When presenting early PCI results during the World Congress of Cardiology in Moscow in 1982, there were only 4 groups, that of Grüntzig in Zürich and Atlanta, Richard Myler in San Francisco, Simon Stertzer in New York, and myself in Frankfurt, who had performed more than several hundred procedures (2). The main reason for this slow evolution was the primitive guidewire technology. After discussing the difficulties with Willy Rutishauser during a long walk in the Swiss Alps, an idea came to my mind to use a separate bare wire instead of the balloon catheter combined with the wire (**Figure 1**).

With this new wire technology, the most difficult part of the procedure, namely traversing the lesion, would become much easier. Steering of the bare wire would be more sensitive and more precise. The visualization of the distal artery was much clearer because contrast injection was not hindered by the obstructing balloon catheter.

The concept was realized with the "long-wire" technique (3,4). After passage of the lesion, the wire was held in place and the appropriate balloon catheter was introduced over the proximal long wire. Any type and size of catheter could be introduced. With the wire as a rail, stents, lasers, rotating instruments, ultrasound catheters, and so on could also be introduced.

When I presented the technique at the Davos meeting in 1984, Grüntzig was present. He was impressed and commented, "Every new method has advantages and disadvantages. What are the disadvantages?" I honestly answered I could see no disadvantage except perhaps the length of the wire. Back in Atlanta, Grüntzig did not introduce the new technique, and it was used essentially in Europe. Only

FIGURE 1 Evolution of Wire Technology



(Top) Grüntzig's wire stump fixed to the distal end of the intracoronary balloon catheter **(green)**; **(middle):** Simpson's moveable wire running through the length of the balloon catheter; **(bottom):** Kaltenbach's bare wire, long for the long-wire technique or short wire as part of the monorail system.

after Bonzel had developed the monorail technique did the bare-wire principle became the standard.

*Martin Kaltenbach, MD
*Goethe University Frankfurt
Falltorweg 8
63303 Dreieich
Germany
E-mail: martinkaltenbach@arcor.de

https://doi.org/10.1016/j.jcin.2017.07.005

Please note: Prof. Kaltenbach has reported that he has no relationships relevant to the contents of this paper to disclose.

REFERENCES

1. Grüntzig A, Hirzel H, Goebel N, Gattiker R, Turina M, Myler R, Stertzer S, Kaltenbach M. Die perkutane transluminale Dilatation chronischer Koronarstenosen [Percutaneous transluminal dilatation of chronic coronary stenoses]. Schweiz Med Wochenschr 1978;108:1721–3.

2. Kaltenbach M. Transluminal angioplasty of coronary arteries. Ter Arkh 1982;54:8–15.

3. Kaltenbach M. Neue Technik zur steuerbaren Ballondilatation von Kranzgefäßverengungen [New technic for guidable balloon dilatation of coronary vessel stenoses]. Z Kardiol 1984;73:669–73.

4. Kaltenbach M. The long wire technique: a new technique for steerable balloon catheter dilatation of coronary artery stenoses. Eur Heart J 1984;5:1004–9.

RESEARCH CORRESPONDENCE

40 Years of Percutaneous Coronary Intervention

A Historical Remark on the Development of the Monorail Technique

The first steps to percutaneous coronary intervention (PCI) with Grüntzig's ground-breaking balloon catheter and the innovative separate use of guidewires and balloon catheters introduced by Martin Kaltenbach are well described in his letter to the editor in this issue of *JACC: Cardiovascular Interventions* (1). This development continued and evolved with the introduction of the monorail-balloon catheter system (including stenting) (2,3).

Our group started PCI at the University Hospital of Freiburg in 1980 after installing a new high-resolution x-ray system. It is important to remember that in the early years, the dilatation success was judged by the decrease of the trans-stenotic pressure gradient. Coronary images were insufficient because of limited radiographic systems and bulky PCI catheters hindering contrast flow through the guide catheter. Thin balloon-on-wire catheters without distal pressure measurement (described by Geoffrey Hartzler and Spencer King) improved contrast flow but had drawbacks in steerability and balloon exchange.

FIGURE 1 1984 Sketch of a "Sliding-Rail Balloon Catheter"

Guidewire with a curved tip. The balloon sits on the guidewire as on a rail. The guidewire is not in a concentric fit within the shaft, but runs parallel to the shaft.

Therefore, the long-wire technique with the concept of "bare wire first" fulfilled many requirements for better PCI procedures. In my view, however, as in the view of others, the evolution of PCI still suffered from lack of ease and from long laboratory working hours. For maximum safety and larger patient numbers, procedures had to be simpler, safer, and shorter. After weeks of thoughts, I came up with a seemingly simple solution, the "sliding-rail system," later called "monorail system." This consisted of a newly designed balloon catheter with a short tube through the balloon segment and a single-lumen shaft, and a short separate guidewire. The relevant inventory step was to desert the long-standing tradition of coaxial catheters (Figure 1). The Schneider Medintag company (Zürich, Switzerland) produced a first version of my catheter to be tested on the kitchen table within 2 weeks!

The monorail catheter dispensed with distal pressure measurement, but could easily slide on any bare wire, also for rapid balloon exchange. To visualize the dilatation result, the thin shaft permitted high contrast flow through the guide catheter, and the balloon could also be pulled back out of the stenosis, whereas it had to stay there to measure the pressure gradient. The other major advantage was the rapid exchange of balloon catheters. The controversy "pressure gradient versus visualization" was debated in many PCI conferences for several years, mostly in the United States, where the acceptance of the monorail technique took longer than in Europe. I remember, at the 10th Anniversary of PTCA Conference in Atlanta in 1987, Richard Myler, in opposition to my arguments, vehemently defended trans-stenotic pressure measurements.

My first public presentation took place in Germany in 1986 at the annual meeting of the German Cardiac Society and in the United States in 1987 at the Annual Scientific Session of the American College of